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Monarca ... Butterfly Beyond Boundaries
Monarca ... papillon sans frontières
Monarca ... mariposa sin fronteras

Rain jacket, sweaters, gloves, toque, heavy sleeping bag ... Could this really be a packing list for Mexico? We were certainly skeptical when our scientific advisor — Dr. Lincoln Brower — tried to warn us about the weather conditions we'd be facing high in the Transvolcanic mountains of Mexico. "It's cold and there could be snow — bring lots of layers," Lincoln advised. Meanwhile, we joked about what someone from the University of Florida could possibly know about cold weather and snow. Nevertheless, we heeded his advice and filled our bags with warm clothing, but there was no convincing our friends and colleagues that we weren't just heading south for a winter vacation!

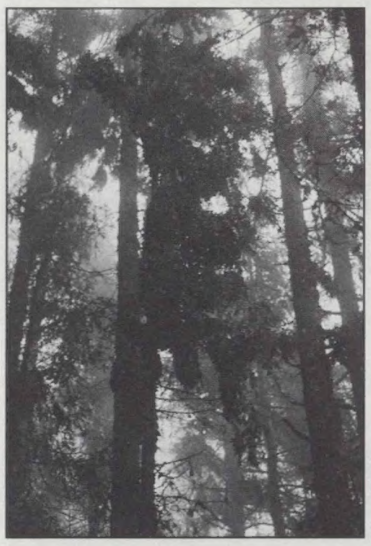
Morag Hutcheson

The expedition drove to altitudes of 3000 meters up tortuous logging roads.

The expedition to Mexico was in fact part of our work on *Monarca ... Butterfly Beyond Boundaries*, a new international travelling exhibit scheduled to open at the Canadian Museum of Nature in June 1993. The exhibit is a collaboration between the Museum, the Canadian Nature Federation (CNF) and Monarca, A.C., a Mexican group dedicated to preserving the monarch butterfly. Although the Museum will take the leading role in the development of the exhibit, CNF and Monarca will be developing educational and conservation initiatives. The trip was planned as an opportunity for the exhibit team — Barry Peers, Ole Neilson, Brian Beaton and myself — to get to know our exhibit partners and experience the overwintering phenomenon of the monarch butterfly first hand.

The expedition began in late January with the exhibit team, accompanied by Ridgeley Williams (programmes director/networking for the Museum) and Jacques Prescott (past president of the CNF), flying to Mexico City. Thanks to flight delays, we met Lincoln Brower and our other scientific consultant, Dr. Bill Calvert, at the airport. All eight of us, plus all our luggage, squeezed into a Volkswagen Combi and set off to brave the traffic of Mexico City. Although we were all anxious to head into the mountains to see the butterflies, we spent the first days in the city. There we met our Mexican partners and had an intense briefing on the biology and conservation of the monarch butterfly. But second-hand information is never as good as hands-on experience ... we were ready to go!

We left Mexico City at 4:00 a.m. (pollution regulations prohibited us from driving the Combi inside city limits after 5:00 a.m.) and drove west into the Sierra Transvolcanica. Entrusting our lives to Barry, we climbed up tortuous logging roads, made more perilous by heavy rains and snow, up 3000 m into a mist-enshrouded forest of Oyamel firs. Finally, we could drive no further.



Morag Hutcheson

The strange cylindrical shapes hanging from the boughs of the fir trees were actually dense clusters of butterflies.

After parking the vehicle in a small clearing we donned our layers of clothing, collected our camera equipment and set out in search of the butterflies. Our bodies were unable to keep up with our enthusiasm as we trekked over steep terrain. The high altitude forced us to slow our pace and take frequent rests to catch our breath. Silence came over the group as we searched for signs of the monarchs. The first clues came in the form of monarch wings littering the ground — victims of birds and mice. Intrigued by the trail of monarchs, we continued to look at the ground — soon hundreds of butterflies were underfoot. These monarchs were casualties of bad weather. Knocked to the ground by heavy storms, they were trapped on the forest floor by the cold. In an effort to get off the ground, the butterflies shivered to warm their bodies and crawled up any vertical surface they could find.

Eventually, we turned our attention upward and to our amazement discovered that the strange cylindrical shapes hanging from the boughs of the fir trees were actually dense clusters of butterflies. We were standing amidst *millions* of butterflies. Heads up, wings folded, they hung onto branches and tree trunks by the tens of thousands.

That first day we lingered amongst the firs and marvelled that the butterflies we had come to know as solitary creatures, had flown thousands of kilometres from Canada to gather by the millions in mountain-top refuges in Mexico.

During the remaining days of the expedition, we visited three more of the nine monarch overwintering sites. Although the striking beauty of the overwintering phenomenon never ceased to mesmerize us, we were alarmed at how many monarchs had been knocked to the ground by the cold, wet, snowy weather. Because monarchs gather in such huge numbers in so few locations, they are extremely vulnerable to natural disasters and what we were experiencing was one of the longest cold, wet spells on record. (We'll never doubt Lincoln's word again!) It remains to be seen whether the mortality suffered by monarch populations last winter will significantly affect the numbers returning this fall.

Driving through the mountains also made us aware of the other threats facing the monarchs. It was clear that butterflies are not the only living things that depend on the forest. Rapid population growth is pushing local farmers farther and farther up the mountainside into monarch habitat in search of trees for fuel and construction, and more land for their crops and cattle.

Barry Peers

Local people plant and nurture Oyamel seedlings to reforest damaged overwintering sites.

We knew that in 1986 President Salinas had taken the first step towards protecting the overwintering sites by setting aside five of the nine sites as reserves, but we were upset to see that the cutting continued. But there were also signs of hope. In a tree nursery inside one of the reserves local people plant and nurture Oyamel seedlings to be used to reforest overwintering sites damaged by logging. At another reserve, local people capitalize on the tourism generated by the butterflies by selling food and handicrafts to visitors. Both of these projects, we learned, had been spearheaded by Monarca.

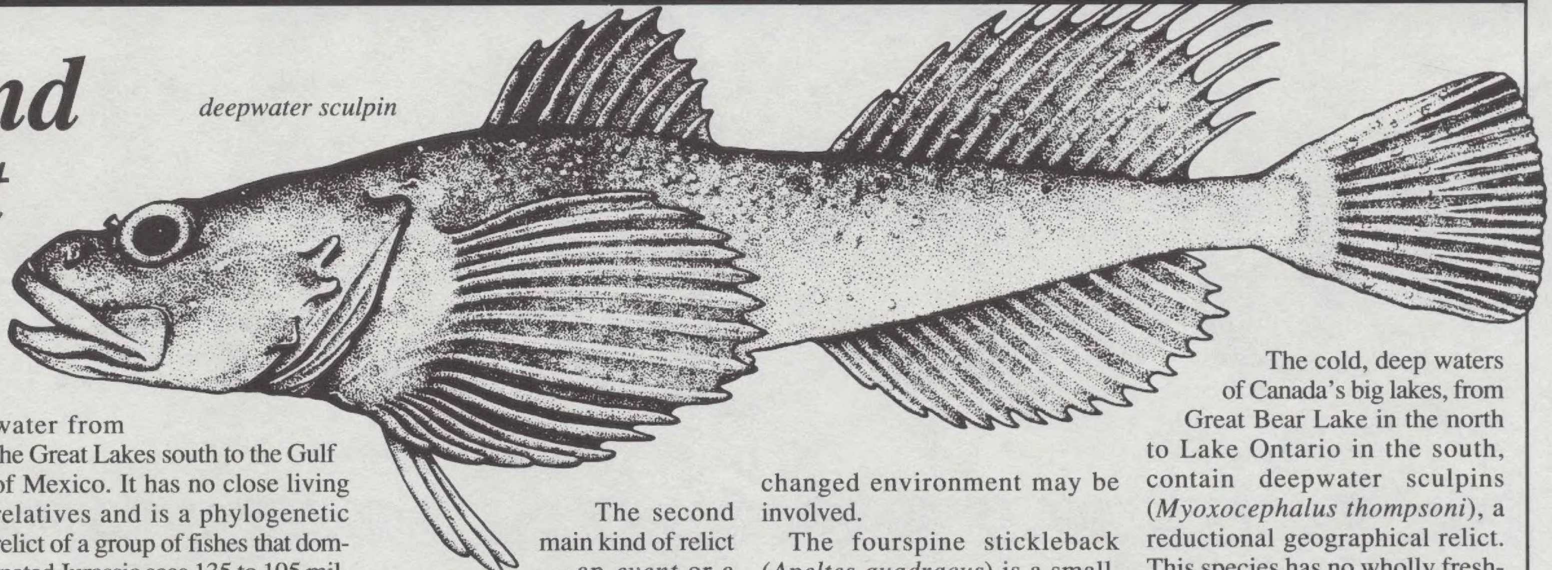
It's been eight months since our return from Mexico but the trip has left its mark. Our impressions have shaped the exhibit's design and content and increased our commitment not only to the exhibit, but also to the protection of the monarch butterfly and its winter and summer habitats.

We have also heard encouraging news. In response to last winter's decimation of the monarchs and to the publicity surrounding Bill Calvert's estimate of monarch mortality, President Salinas recently announced that the butterfly reserves are to be enlarged and money is to be spent on conserving the forests. In Canada, news of high monarch mortality has prompted inquiries by the media and the public.

Even though the exhibit has yet to be built, the team senses that it has already contributed, in a small way, to the preservation of the overwintering sites of the monarch.

Morag Hutcheson
Exhibit Developer, Monarca Project

Relicts and the Past



deepwater sculpin

Time marches on ... or does it? For 'relict' species, time seems to have stopped. These organisms are the Rip Van Winkles of the biological world.

Relicts, where evolution has been arrested or slowed down, are often referred to as 'living fossils.' Called *phylogenetic* or *evolutionary* relicts by scientists, living fossils are one of the two main kinds of relicts. These living species are very similar to known fossil species that are usually millions of years old. The living species has few or no existing relatives. A living fossil retains archaic characters now lost in more modern forms. Its anatomy enables us to deduce things about the fossil — for example, the arrangement of muscles and other soft parts that do not readily fossilize — and aids in confirming and expanding our interpretations of incomplete fossil remains. The physiology, biochemistry, life history and behaviour of the living fossil can be determined either in the field or the laboratory. Although a living fossil may be a rare representative of its lineage — a survivor of the past — it can be quite common and familiar.

The bowfin (*Amia calva*) is found in heavily vegetated, fresh water from the Great Lakes south to the Gulf of Mexico. It has no close living relatives and is a phylogenetic relict of a group of fishes that dominated Jurassic seas 135 to 195 million years ago. It is the only living representative of the taxonomic subdivision Halecomorphi and ranks equally with the more than 20,000 teleost subdivision species, comprising about 96 per cent of all living fishes. The genus *Amia* has been around for 70 million years, indicating that evolution can be very slow. The bowfin has a unique double jaw articulation, a primitive, part-bone, part-cartilage skeleton, and many other characters found in less advanced fishes. However it does possess some evolutionary advances. For example, it uses the swimbladder as a primitive lung and has a highly developed system of caring for its young. Despite its status as a living fossil, it is a successful predator and competes well with more 'modern' fishes.

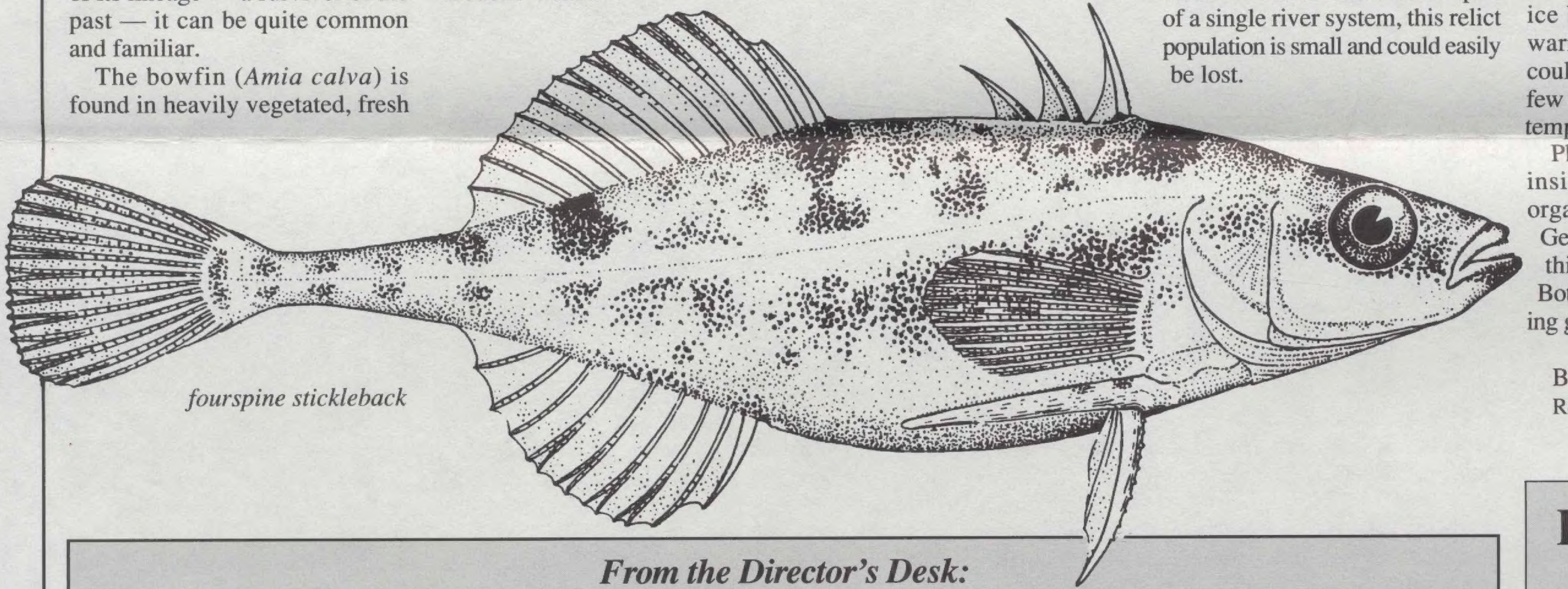
The second main kind of relict — an *event* or a *geographical* relict — is an animal or plant that tells us something about a past environment. These relicts are characterized by their distribution and are considered disjunct or reductional. A *disjunct* geographical relict is often a common species with many living relatives but its current populations are found outside the normal range of the species or in an unusual or isolated habitat, sometimes called a refugium. A *reductional* geographical relict is similar to a disjunct relict, except the species is extinct outside the limited habitat; a formerly widespread species has become restricted in its distribution. Geographical relicts often owe their origin to climatic events, but any kind of habitat factor or changed environment may be involved.

The fourspine stickleback (*Apeltes quadracus*) is a small, Atlantic coast fish. It is primarily marine but some populations exist in freshwater, often with some access to the sea. However, one of these populations is isolated above a waterfall in the Matamek River on the north shore of the Gulf of St. Lawrence and there are no marine populations nearby. It does not appear to differ from marine populations and is not regarded as distinct. This freshwater population is thought to be a disjunct geographical relict of a warmer period from five to seven thousand years ago. The fourspines entered the Matamek River system from the sea before the formation of the waterfall and survive today while neighbouring marine populations have been eliminated or became rare as the climate cooled. Limited to one part of a single river system, this relict population is small and could easily be lost.

The cold, deep waters of Canada's big lakes, from Great Bear Lake in the north to Lake Ontario in the south, contain deepwater sculpins (*Myoxocephalus thompsoni*), a reductional geographical relict. This species has no wholly freshwater relatives. Analysis of its body structures show it is most closely related to the fourhorn sculpin (*Myoxocephalus quadricornis*) of shallow, coastal brackish and neighbouring fresh waters. The deepwater sculpin evidently originated from marine ancestors, but how did it become isolated in the deep waters of inland lakes over such a large area? One theory is that the ancestors of the deepwater sculpin entered fresh water during the Wisconsin glaciation (which began about 60,000 years ago), which resulted in a southern movement of freshwater populations into great glacial lakes in front of the ice sheets. Here the deepwater sculpin could have evolved from an ancestor similar to the fourhorn sculpin. Later (17,000 years ago), as the ice began to retreat and waters warmed, the deepwater sculpin could have become restricted to a few deep lakes where suitable cold temperatures were to be found.

Phylogenetic relicts give us an insight into how related fossil organisms lived and functioned. Geographical relicts tell us something about past environments. Both offer fascinating and intriguing glimpses of lost worlds.

Brian W. Coad
Research Division



fourspine stickleback

From the Director's Desk:

How Important are Decisions Made by Natural History Museums?

In the complexities of modern times, it is often difficult and confusing to find the correct decisions. So many factors seem to pull in different directions. In business, when faced with an important question, the result of an incorrect decision can often spell the difference between financial success or failure. What is the consequence of an incorrect decision on an important issue in a museum of natural history? Perhaps the first question should be: are there any important issues faced by natural history museums? The Canadian Museum of Nature is also a business. It employs over 250 staff, who are housed in 13 different and widely scattered buildings in the National Capital Region in both Ontario and Quebec. The annual budget exceeds $21,000,000. An incorrect decision in the Museum can also spell the difference between financial success and failure.

Unlike the failure of a business, however, where it simply means that someone won't be able to buy a Hula Hoop, or have a Super Burger, it can be far more devastating.

The most important decisions a museum of natural history makes are scientific. Often the apparently minor and relatively unknown species that are hard to identify can mean life or death to some person, or to many people. Identification of crop-damaging insects, the host organisms that carry parasites, the life cycles of little-known soil organisms, the evolutionary interrelationships among closely related plants are all questions tackled by museum scientists on a daily basis.

One very disturbing and frightening observation comes from examination of the paleontological history of the world. Many examples of major losses of world biodiversity have occurred in the past 500,000,000 years. One of the most famous, but not the most severe, occurred 65,000,000 years ago, when the dinosaurs, along with many other species of creatures and plants, died forever. Many science fiction writers have predicted what would happen in a modern instance: a few of the dominant forms would survive, including humans. These remnants of the dominant forms would then reshape the world. Unfortunately for us, the overwhelming weight of past evidence is that this would not happen.

The disturbing and frightening observation is this: repeatedly in these real losses of biodiversity, the dominant species are all lost. It is the rare and uncommon that take over. Humankind is a dominant species today. If the pattern were to repeat itself in the face of a modern loss of biodiversity, humans are in serious danger of extinction! The current rate of loss of world biodiversity is about the same as when the dinosaurs disappeared. Although difficult to predict when the losses would be of similar proportions, assuming no changes in rates, it is likely this would occur within the lifespan of great-grandchildren of today's children.

How important are decisions made by natural history museums? They could be the most important decisions that will ever be made by any human beings in the short history of humankind.

Alan R. Emery
Director

BIOME

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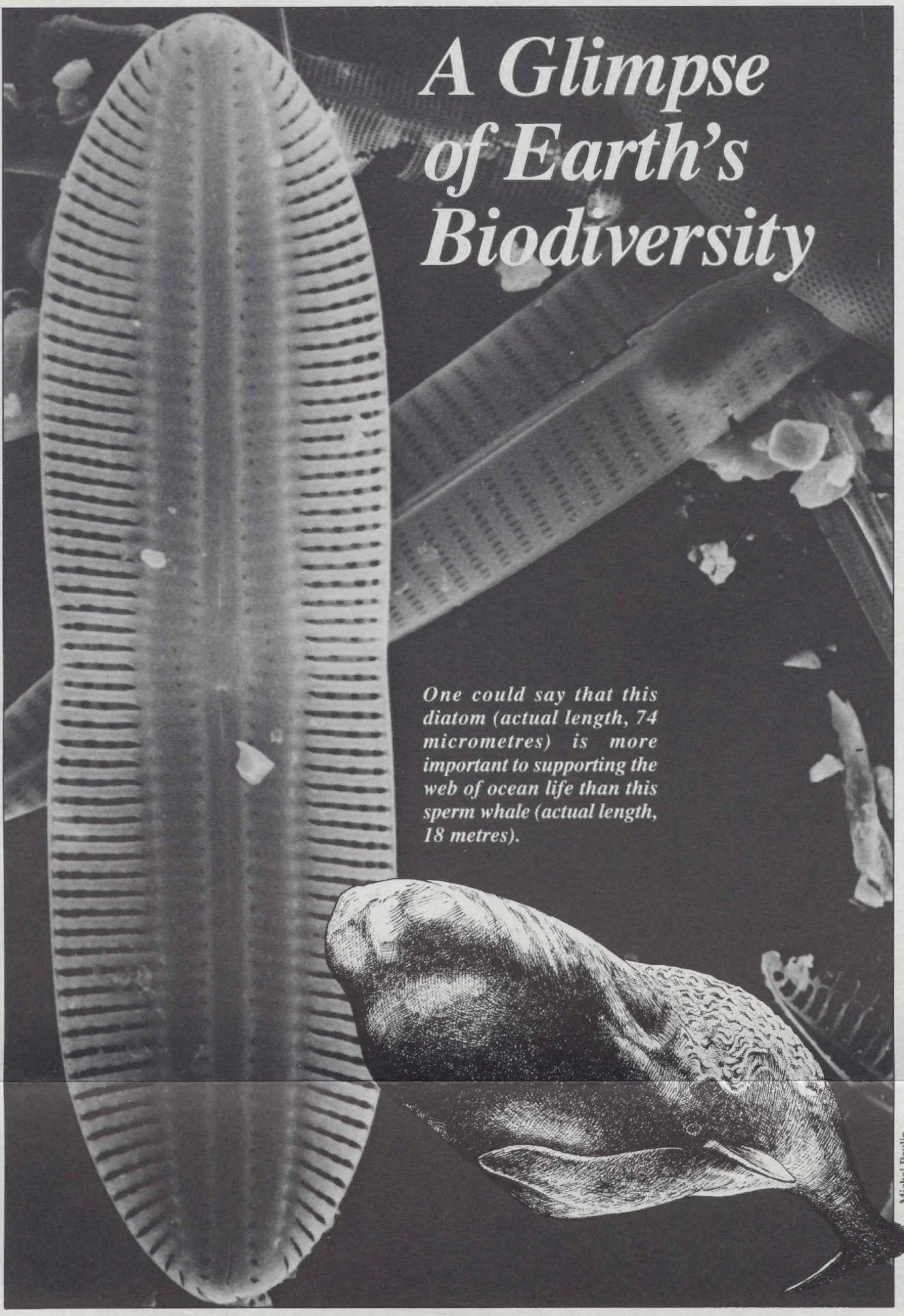
A Glimpse of Earth's Biodiversity



One could say that this diatom (actual length, 74 micrometres) is more important to supporting the web of ocean life than this sperm whale (actual length, 18 metres).

Michel Poulin

Biodiversity is a word that is being increasingly used in media reports about environmental issues. It was the centrepiece of discussion and contention during the Earth Summit last June. But just what is biodiversity?

Biodiversity is the rainbow variety of life on Earth, or on some portion of it. There are three components: the genetic or hereditary; the species or taxonomic; and the ecosystem or habitat diversity. Biodiversity is intimately linked to the rest of the planet's ecosphere — the atmosphere, the hydrosphere and the lithosphere (soil and rocks). The ecosphere gave birth to life and life has given birth to the ecosphere as we now know it. Today's biodiversity is the product of 3.5 billion years of evolution. Biodiversity's complexity at all levels is scarcely known, yet it is fast disappearing from the planet.

Genetic or Hereditary Diversity

Genetic diversity is almost overwhelming. Three billion nucleotide 'letters' encode the approximately 75,000 genes on the 23 pairs of human chromosomes. Some life forms have even more genes, or hereditary units, and some have far fewer. Genes provide the 'blueprints' that grow a fertilized egg, seed or spore into an adult and provide operating instructions to run the body internally and to regulate how it interacts with the surrounding environment.

A set of genes, called a genome, distinguishes one species from another and allows for individual variation within species. The genes in a genome have been selected by evolution over thousands or millions of years to adapt a species to its natural environment. If humans change the environment too rapidly, the blueprints will no longer contain instructions appropriate for survival — another species is lost.

Knowledge about the genome in a species is precious. This knowledge will lead to cures for human diseases, plants that can withstand frost better, crops that need less fertilizer and inexpensive methods of producing useful organic chemicals. The gene responsible for asthma and the one responsible for bowel cancer have already been discovered. In June, the government announced a $12 million grant in support of the Human Genome Project to study and map human genes.

Species or Taxonomic Diversity

Species diversity is commonly measured in the number of species found in a given region or on the whole planet. Canada has about 280,000 species and Costa Rica 505,000. Estimates of the number of species on the planet range from 10 to 100 million. But of those many millions of species, only 1.5 million have been discovered, named and classified by taxonomists.

Species are grouped in a tree-like form into genera, families, orders, classes, phyla and kingdoms. Taxonomic diversity covers every living thing; almost 100 phyla make up these five kingdoms: the Prokaryotae or bacteria; the Proctistia embracing the seaweeds, slime moulds, ciliates and other water dwellers; the Fungi, which include mushrooms and moulds; the Plantae or green plants; and the Animalia, which include the animals with and without backbones. The viruses may have a composite origin, with multiple origins from plant, animal and other host groups. They might even represent a distinct sixth kingdom sharing a single common viral ancestor. Taxonomists are still trying to perfect our knowledge of relationships in the vast and ancient tree of life.

Conservation efforts started out by focusing on air-breathing vertebrates such as birds and mammals and are now extending to include flowering plants, fishes and butterflies. But shouldn't we care for all life? The smallest species — those that live in water and in soil — have been all but ignored. One could say that diatoms, algae found at the base of several food chains, are more important to supporting the web of ocean life than whales. Tiny root fungi (mycorrhizae) nourish the roots of 80% of seed plants; forests, prairies and crops depend on them. The fate of the planet may lie in protecting the mini- as well as the macro- life-forms.

Ecosystem Diversity

The diversity of ecosystems is vast: tall grass prairies and temperate rainforests; seagrass beds and kelp thickets; mangrove swamps and coral reefs; prairie loams and deep sea sediments composed of diatoms. There is variety within ecosystems as well — the spruce forests at the Arctic treeline are much less diverse and 'mooseless' compared with spruce forests in Ontario. We are as ignorant about ecosystems as we are ignorant about genomes, species and their interrelationships. Only recently have we learned that alders and arboreal lichens provide nitrogen to forest soils.

Genes, species and ecosystems perform at least 20 ecological functions that sustain the ecosphere and humankind. For example: insects pollinate flowering plants; worms aerate soil and permit rain to penetrate instead of erode the soil; forests provide a three-dimensional habitat for a myriad of creatures; and plant plankton help maintain the planet's oxygen supply. It is not enough to create protected areas, like arks, to preserve a handful of each species. Enough diversity must be retained in substantive parks, naturally managed forests and organically managed farms, to sustain the Earth's life support systems. Protecting 12% of a country's land and water in parks is clearly not enough ecological support if the remaining 88% is bare-ploughed, clearcut or paved.

In view of the accelerating loss of biodiversity, there is a need for research, education, conservation, funding and action. Agreements made at the Earth Summit in Rio de Janeiro may not be precise and strong enough to set new courses for the world's governments. But the process at least has educated those governments to a much higher level of awareness.

Last year the Canadian Museum of Nature began publishing *Canadian Biodiversity* (*Bulletin canadien de la biodiversité*). This quarterly bulletin tries to present up-to-date information on biodiversity in an easy-to-read style. Yearly subscriptions cost $25 for individuals and $50 for institutions. *Caring for the Earth* (228 pages), a comprehensive survey of worldwide conservation and development, is also available from the Museum for $16.95.

Biodiversity is tiny ocean plankton that glow like green sparks; speedy blue-bodied dragonflies; slender threads of fungus measuring hundreds of meters in a single handful of soil, providing support for huge trees; coral reefs, bejewelled with colourful fishes and nudibranchs; a Whitethroated Sparrow's evening song. Can we learn to care for our fellow lifeforms, big and small? Let's act and share.

Don E. McAllister
Canadian Centre for Biodiversity

Spiders

A few facts from our new issue in the *Neotoma* series: There are about 30,000 species of spiders grouped into some 105 families worldwide. In Canada there are 1256 species in 33 families.

Contrary to what many people may think, spiders are not closely related to insects. As arachnids, their closest relatives are mites, ticks, pseudoscorpions and scorpions.

Most spiders are relatively small — an average of 2-10 mm long — but some large tropical bird spiders reach a body length of 80-90 mm.

Many people believe that males are eaten by females after mating. This is true for only a few spiders and it does not invariably occur.

All spiders (except for the Uloboridae) are venomous, but only about 20 to 30 species carry venom considered dangerous to humans. The only dangerous spider known to occur in Canada is the black widow, *Latrodectus mactans*.

Do you want to find out more about these mysterious and little-understood creatures? Then write to the Museum Resource Centre for your free copy of *Neotoma* issue 33, *Spiders*. A list of our other free materials is also available on request.

A Colossal Flower!

Gigantism, in the biological sense, is the development of an organism to an abnormally large size. Throughout the history of our Earth, several groups of plants and animals have produced species larger than the norm. Perhaps the first to come to mind are the giant dinosaurs of the Late Mesozoic Era (140 to 65 million years ago) and the exceptionally large dragonflies of the Carboniferous Age (310 million years ago).

Today, gigantism may not be as obvious, yet large-sized members still exist in nearly all groups of organisms, especially in the animal kingdom. The long-horned beetle (*Titanus giganteus*) of the Amazon Basin may grow 15 cm to 19 cm in body length — truly a giant among insects. The largest fish, the whale shark (*Rhincodon typus*), common in waters of the Caribbean and Gulf of California, has been measured at 18 m. The giant clam (*Tridacna gigas*), which also lives in marine waters, can grow to 1.3 m in length and weigh up to 264 kg.

In the plant kingdom, the giant sequoia (*Sequoiadendron giganteum*) and the coast redwood (*Sequoia sempervirens*) of California are cited as the largest trees in the world. The giant sequoia can grow to 100 m high and 8 m wide. Less known to most of us are the extreme sizes of fruits and flowers that some tropical plants produce. The coco-de-mer (*Lodoicea maldivica*), a palm tree of the Seychelles (an Indian Ocean island group), produces a seed that can weigh as much as 30 kg.

Of special note is the largest flower on Earth, past or present. Deep in the tropical jungles of Indonesia and Malaysia, growing low to the ground, is *Rafflesia arnoldii*, which produces a foul-smelling, brilliant brick-red speckled flower measuring 1 m in diameter and weighing about 7 kg! The Rafflesias, distant members of the rose family, are parasites and gather their nourishment from fine root hairs imbedded deep in the root or stem of their host plant. As parasites, they produce neither stems nor leaves but direct all their energy to developing their colossal flower.

Why should a flower be so big? Biologists studying the Rafflesias do not believe size has any real advantage. Smaller flowers, growing in groups called inflorescences (like our dandelions and Queen Ann's lace), produce thousands of small seeds, easily dispersed by wind currents. A single Rafflesia flower can produce up to four million seeds, but no matter how many seeds are produced, propagation would not be guaranteed if these seeds merely fell in a heap beside the wilting and rotting flower. The seeds must be dispersed to find their own host plant on which to grow and parasitize. This is where the foul smell, which has been compared to the odour of rotting meat, comes into play. Although nauseating to humans, the 'fragrance' attracts tree shrews, squirrels and other small mammals that feast on the numerous seeds and scatter them around the forest floor. Eventually, some seeds end up near the proper host plant, germinate, attack the root system of the host plant, and begin another generation of Rafflesias.

A giant Rafflesia flower, showing the five speckled petals surrounding the disc of seed-producing organs protected in the crater-like central bowl.

Being the largest of anything can have its drawbacks. Since *Rafflesia arnoldii* was officially discovered by the explorer Sir Thomas Stamford Raffles (founder of Singapore) and the naturalist Joseph Arnold in 1818 (and now bearing their Latinized names), it has attracted tourists who come to marvel at the giant flower. With its inclusion in the *Guiness Book of World Records*, the flower has in recent years suffered increased trampling and seed collection by curious tourists. Today, this is a real "Catch-22" situation in that tourists are contributing to the Rafflesia's demise while tourist dollars are paying for the preservation of the plant's habitat.

Governments, travel agencies and biologists will need to work together to find acceptable limits to tourism and ensure the survival of this remarkable and colossal flower.

David M. Jarzen
Research Division

The Activity Corner:

Let it Snow, Let it Snow, Let it Snow

Once again, Canadians are experiencing (or soon will be) their love-hate relationship with snow. Snow means hours of entertainment on skis, snowshoes and snowmobiles. But removing the 'white stuff' from sidewalks and driveways also means aching backs! Even if your outdoor winter exercise is limited to shovelling, the following activities may help you appreciate snow a little more.

Observing Snowflakes

This activity works best during periods of light to moderate snowfall. You will need a 30 cm by 45 cm piece of black material such as felt or velveteen, a piece of cardboard and a hand lens:

- Place the material in your freezer for about 15 minutes before going outside.
- Spread the material flat on the cardboard and allow snowflakes to settle on it.
- Observe the snowflakes through the hand lens.
- Marvel at the unique and intricate pattern of every flake.

Measuring Snowfall

You will need a metre stick, waterproof tape, a one- or two-litre can and gravel or sand:

Tape the metre stick to the can — add some sand or gravel so the can stays upright.

- Place the apparatus in an area unobstructed by buildings or trees (it may be partially buried in existing snow for added support).
- Take readings after each snowfall, subtracting the old surface level from the new one to determine the amount of snowfall.

To record your observations, make a chart with these headings: date, time, temperature, type of snowflake and amount of snowfall. How many sides or main points to each basic type of snowflake? Did you observe heavier snowfalls during warmer or colder temperatures? Which types of snowflakes were most common during these warmer or colder temperatures?

Snow is a natural insulator and lessens the effects of severe temperature fluctuations that soil and plants are subjected to. Snow also reduces the amount of water lost in dormant plants. So try to think positively while driving through a snarl of traffic during a winter storm or while massaging those aching muscles!

Mary Anne Dancey